Thoughts on a Different TASD Far Detector Structure

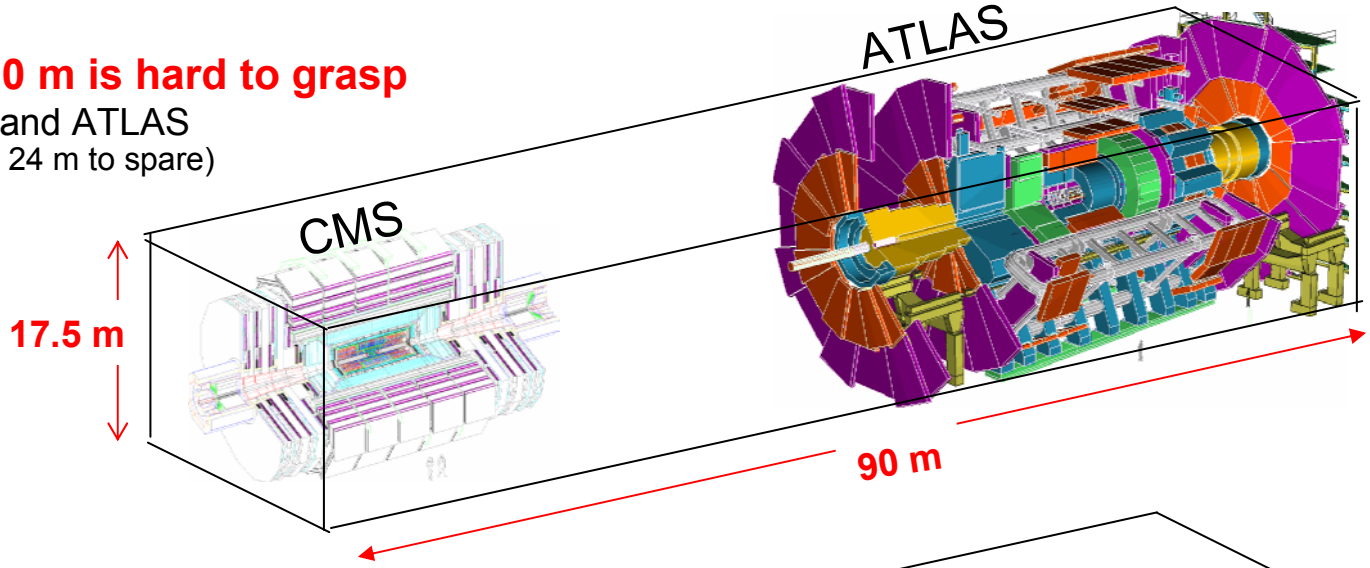
John Cooper

NOνA CollaborationMeeting

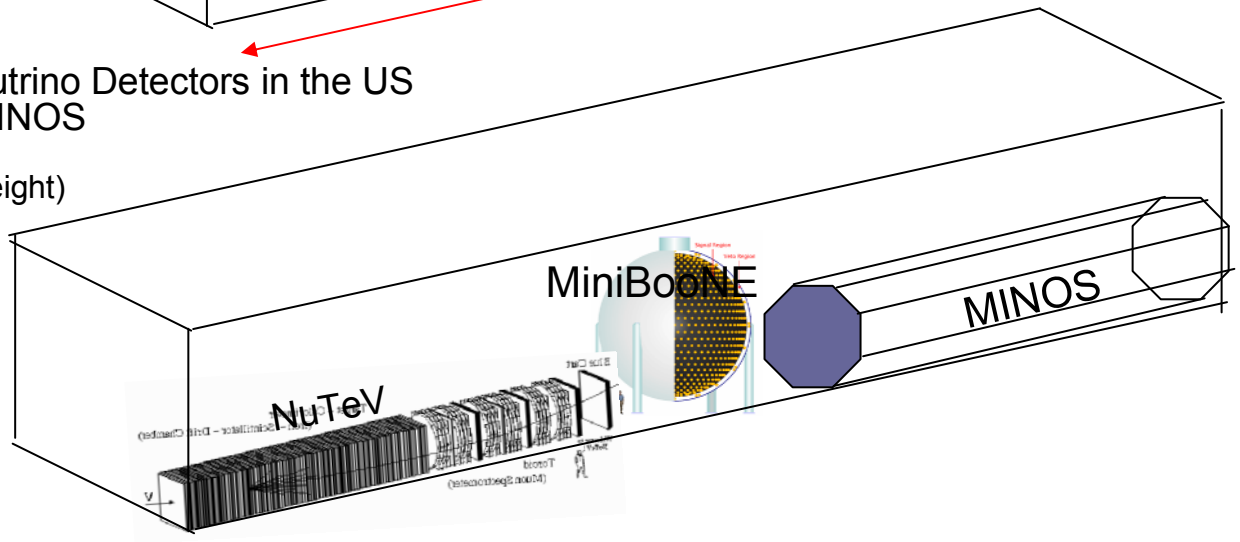
October 3, 2004

NOνA is a BIG detector

- **17.5 m x 17.5 m x 90 m is hard to grasp**
  - Compare to CMS and ATLAS
    (they fit inside with 24 m to spare)

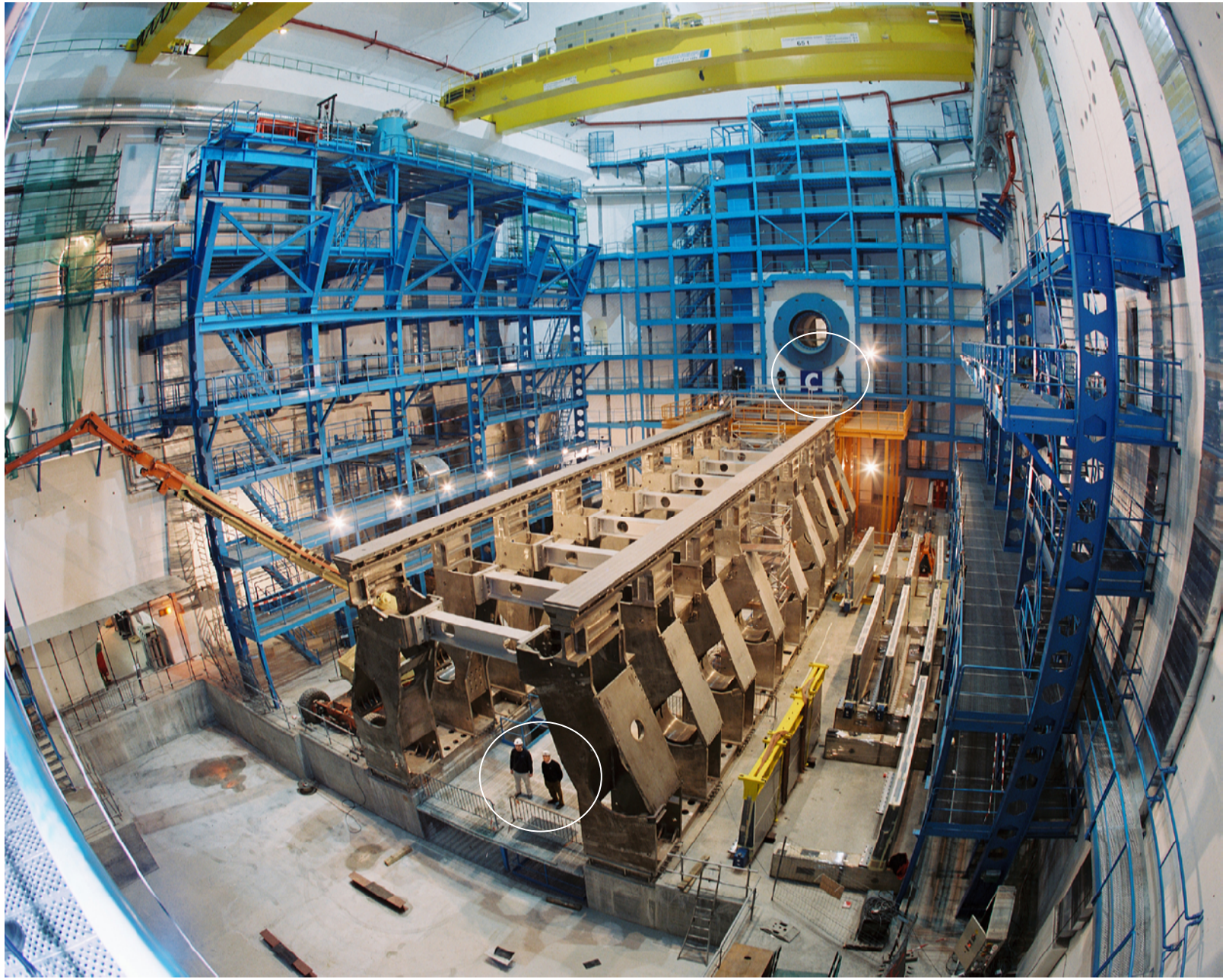


  - Compare to previous Neutrino Detectors in the US
    NuTeV, MiniBooNE, MINOS
    (almost as long, but only a
    fraction of the width and height)



So we have to fill the ATLAS cavern TWICE

The ATLAS cavern



Do we really want to fill this volume with a monlithic glued plastic structure ?

- Maybe the engineering calculations will indicate it can be done
  - The jury is still out, yet we will have to decide in January
  - So having a backup concept seems reasonable
- Even if it looks like it **could** be done,
  we should still think about if it **should** be done
- My gut feeling is that in spite of our best design & construction effort,
  - some parts of this structure will come apart, will develop leaks,…
  - Even attaching electronics to it makes me uneasy
  - Filling all the cells distributed in a volume this large seems hard

So, what about modular solutions?

- Why modular?
  - Some hope that the supporting structure could be more robust and more easily understood mechanically.
- In the past I have pushed shipping containers as a modular solution
  - I came at the problem thinking the 20-foot long ISO containers were a cheap solution when coupled with a cheap absorber
    - They weren't cheap enough, …
  - & people did not like the cracks

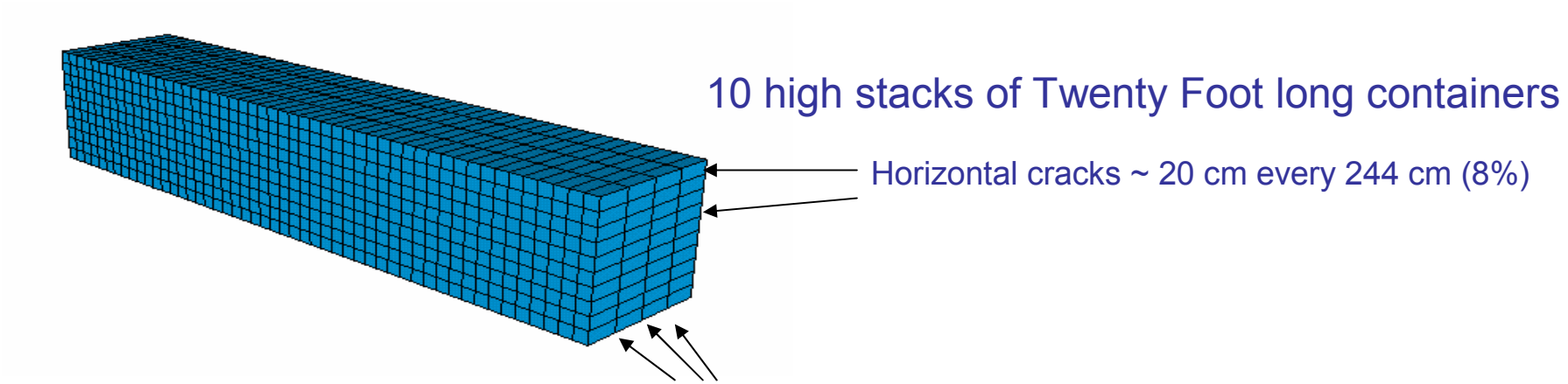


Figure 1. A 4x10x50 Container Array

What about TASD modules?

- Start with some practical considerations
- The largest object easily transported by truck is 8.5’ wide, 9.5’ high, and 53’ long
  - Rail offers other solutions but is not likely to be an option at our Far site.
  - One quick lesson:
    - We should NOT be thinking of a 17.5 m scale (57’) in any case (see Stan’s note #43).
    - 53’ including manifolds is the max
- The road weight limits for any truck are 100,000 lb for the combination of the tractor, chassis trailer, and payload module
  - Even at 100,000 lb, there will be a modest fee – the no-fee limit is only 80,000 lb
  - The accepted tractor + chassis trailer weight is 37,000 lb
  - This leaves only 63,000 lb for the payload

Combining this size and weight:

- The internal volume of a 8.5’ x 9.5’ x 53’ object is about 108 m^3
- TASD density is 0.9 g/cc
- So the weights associated with this max volume are
  - Full = 97.2 metric ton = 214,000 lb — too heavy
  - Plastic only (15%) = 32,000 lb — OK
  - With half the cells full = 107,000 lb — still too heavy

53-foot long ISO containers

- These are a standard item for US Domestic trade
  - Made by adding simple extensions to both ends of the 40ft version
  - As built with steel they have a tare (empty) weight of ~10,000 lb
  - They advertise a payload capacity of ~ 70,000 lb
  - But they are way over-designed and in fact can hold 145,000 lb within appropriate safety factors easily calculated for steel construction

- These have 8 posts with the four at the 40 ft positions being the strong ISO spec versions capable of 190,000 lb loads each.
  - Could stack 5 on 1 (4 posts *190,000 / 145,000 per box = 5.24)
  - This is 6*9.5 ft = 57 ft (or 17.4m)

- This looks interesting because the vertical cracks go away for a detector 53 ft (or 16.1 m) wide

- But a max payload of 145,000 lb means
  - A density of 0.68 (so about 25% of the interior would have to be air)
  - & 145,000 lb payload + 10,000 lb tare weight can't meet the road limit

How about a custom container

- Same as a standard 53 ft,
  but only 5 ft wide (still 9.5 ft tall)
  - Would have a tare (empty) weight of <10,000 lb
  - Would still have a payload capacity of ~ 145,000 lb
  - Could still stack 5 on 1 (same posts)
    - » Recall we can connect the corner blocks for more stability

- Now we can get the TASD density

- & the weights associated with this max volume are
  - Full = 62 metric ton = 126,000 lb + 10,000 tare too heavy
  - Plastic only (15%) = 19,000 lb OK
  - With half the cells full = 53,000 lb + 10,000 tare **exactly OK**

Even more custom

5 ft
~ one door

- Replace the standard container floor and roof
  - Remove 1 inch of plywood, replace with 3mm steel
  - Thin the supporting members under the floor
    - Add another 3mm steel underneath to make a box beam
    - Removing 3 more inches clearly possible, maybe more
  - Replace the corrugated roof with a flat sheet and gain another inch
- The net result is the horizontal crack between stacked containers can be reduced below 7.5 cm
- AND
  - The roof could be aluminum
  - The side walls could be aluminum
  - Perhaps the floor could be aluminum as well
  - Retain the steel posts at 40’ (cantilever) and the top / bottom rails
  - So, a strong steel box with an aluminum shell

Advantages of this modular scheme

- Solves my concern about the structure of this large detector
  - We rely on engineering calculations of steel (aluminum) structures
  - The PVC plastic parts are only 9.5 feet high, low stress
- Multiple construction factories are possible since we can move the modules
  - Take advantage of cheap labor at home
  - Gives work to collaborating institutions
  - Easier to attract new collaborators?
    - E.g. China for the containers?
- Modules are transportable empty & half full
  - Could fill the vertical cells at university factories, do the check-out
  - Fill the horizontal cells at the Far site
    - And the fill end can be separate from the fiber end in the horizontal cells
    - Also could tilt the containers slightly if bubbles matter
- Modules are transportable in the future as well
  - Just empty the horizontal cells again and you can move it on the road
  - This is a major sales point for an extended neutrino program

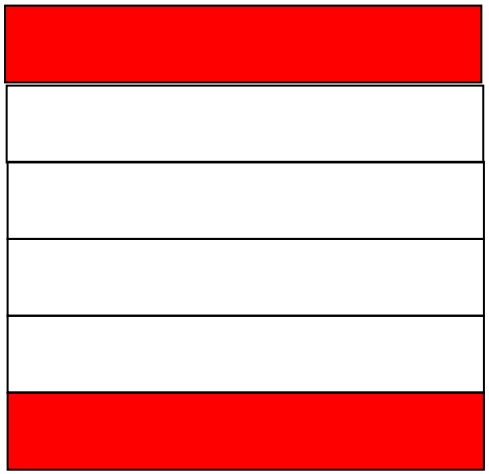
More Advantages of modules

- The modules serve as secondary containment
  - Blunts any environmental concern
  - First the 32 cell extrusions are the typical maximum credible accident and now most are smaller in volume, AND we can find the leak inside the container and swap out the module to clean it up
- The filling system is much simpler
  - All modules can be filled in one 5 ft x 53 ft location inside a bathtub containment versus a distributed system 57 ft x 300 ft with some parts 57 ft in the air
  - Once filled at the "filling station", we use a crane to position the 68 ton modules
- Staging the detector (an explicit question from the PAC to us) is more obviously done with modules in the likely tight funding scenarios of FY07, FY08, and FY09.
  - E.g., start with 25% of the building
    - If first construction funds in Oct 2006, still must do final design, bid, and at least a 180 day construction
    - This means no place to build the detector until at least Oct 2007, maybe April 2008 if weather plays a role
    - Even this funding scenario could be optimistic by a year
  - In parallel, we can build 10 - 25% of the detector modules ELSEWHERE
    - Assembly at the Far site can be rapid once we get building occupancy

Even more Advantages of modules

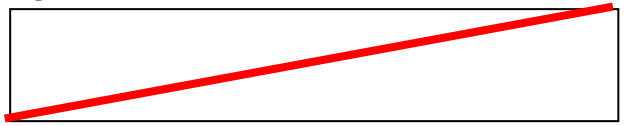
- If we are wrong about needing an overburden, then we can recover easily
  - @ 136,000 lb for the 5 ft x 53 ft modules, the four posts mean we can stack as high as 5.6 on 1, giving 0.6 modules worth of overburden capacity (1.75 m water equiv)
  - Actually way more than this, since the 190,000 per post is “at sea” with a 1.8 safety factor and “on land” we can use a safety factor of 1.5
  - This means it’s possible to stack 6.7 on 1, so there is an overburden capacity of 1.7 modules worth (5 m water equiv)
  - And really there are EIGHT posts, so the limit is likely much higher

- Maybe it would be useful to have a portion of the detector completely shielded by live scintillator in both views?



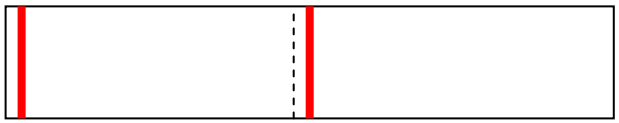
Yes, Disadvantages also

- Still those cracks
  - Though now no vertical ones
  - Horizontal ones are likely < 7.5 cm (2.5% dead), likely much less material than what has already been simulated with the RPC designs
  - Needs more simulation in TASD
- Increased electronics channel count drives up the price
  - 6 channels / vertical cell vs. only 1 if 17.5 m long means 3.5 * $
  - Possible schemes to mitigate this:
    - Wider vertical cells (we need to simulate width with pulse height)
    - Shallow angle stereo?



This results in only 2* the horizontal channel count @ 10^0 or overall only 1.5* the electronics $

    - Multiplexing schemes?



Two strips separated by 7.5 m to the same APD pixel
Overall only 2* the electronics $
Perhaps one un-multiplexed layer per container to remove ambiguities?
(Harder to do this if 17 m long)

I am encouraged

- For January:
  - Will continue engineering study
  - Will look at costs for some final scheme
  - Hopefully can get TASD simulation of same

- Recall my talk to the DOE – next slide

Repeating a slide from the DOE presentation:

What might we learn in such a ν program?

- Something is very different between the quark and lepton sectors, so we might dream there's something major to be discovered here.
  - In the beginning of the collider program:
    - Nobody dreamed of finding a top quark of mass 175 GeV
    - They didn't really even dream of doing b-quark physics
      - » look at the CDF Design Report of 1981
        - – it's all about W and Z and jets
  - As with top and b-physics in the collider program, **we may not even know** what the new neutrino things are yet
    - e.g., what if MiniBooNE does see the LSND signal?
    - Whatever the unknown, will our detectors have enough flexibility to follow up when it appears? The collider detectors did.
  - **That's the excitement of this field**
  - And it is driven by pot*kT
  - despite various detector (calorimeter) types,
  - despite various detector positions of on-axis or off-axis

Flexibility:

this was a backup slide in the DOE presentation

- What if the physics in 2015 requires something NOνA doesn't have?
  - Based on the collider & neutrino (!) histories, we should NOT think we know everything right now for a 25 year long program.
  - e.g. what if we eventually do need a magnetic field like MINOS (recall CDF and DZero on solenoids).
    - Maybe a more modular detector would allow a retrofit magnetic field for μ sign determination. e.g., leave periodic gaps for future thin toroids - extra initial cost.
- What about moving NOνA?
  - extends the life of the initial investment at the point of adding the Proton Driver since the likely scenario is to have a large detector at the second oscillation maximum
    - **There are schemes with transportable shipping containers** or with floating detectors on Lake Superior that could give this flexibility.
    - **In my discussions with collider people this does sell well !**
      - Radical example: the Henderson mine shaft is 28 feet in diameter, and we should be considering such a modular scale.
- I worry that the our project system time scale doesn't allow rapid response to a changing physics landscape
  - It is best to build in possible cheap modifications from the start.
  - But Collaborations, PACs, even P5s don't weigh this factor enough.